

Certification of Vapor Phase Hydrogen Peroxide Sterilization Process for Spacecraft Application

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In order to meet NASA planetary protection mission category IVB microbial reduction requirements for all Mars in-situ life detection and sample return missions, entire planetary spacecraft (including planetary entry probes and planetary landing capsules) may have to be exposed to a qualified sterilization process. Presently, dry heat (~110°C for 47 hours) is the only NASA approved sterilization technique available for spacecraft application. However, with the use of various man-made materials, highly sophisticated electronic circuit boards and sensors in a modern spacecraft, compatibility issues may render this process unacceptable to design engineers and thus impractical to achieve terminal sterilization of entire spacecraft. An alternative sterilization technique that is heavily used in the medical industry is a low temperature (25 to 45°C) vapor phase hydrogen peroxide sterilization process. In order to have hydrogen peroxide as a NASA approved sterilization technique, the following issues need to be addressed.

1. Develop a three dimensional model to predict dead space and hydrogen peroxide concentration profile in a fairly large sterilization chamber (large enough to accommodate a spacecraft) for a selected H₂O₂ injection mode and sterilization cycle.
2. Identify all organisms (including hardy ones) normally found in spacecraft assembly facilities.
3. Experimentally demonstrate that this process is effective to kill all hardy microbes deposited on exposed, in between overlapped, and hard to reach surfaces at a minimum sterilization temperature, and H₂O₂ concentration. Also this process should be effective enough for all surface types such as metallic, composite, polymer, etc.
4. Establish a complete sterilization cycle and procedures that can be adopted to sterilize a spacecraft.

This paper will address these issues and discuss work that are planned to be conducted at JPL in order to have hydrogen peroxide as a NASA approved sterilization technique for various spacecraft parts/components and also entire modern spacecraft.